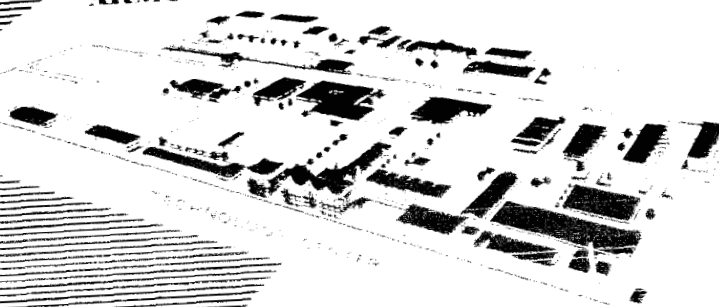


W 82 11063



ARF 3194-1
(Quarterly Status Report)

ARMOUR RESEARCH FOUNDATION OF ILLINOIS INSTITUTE OF TECHNOLOGY



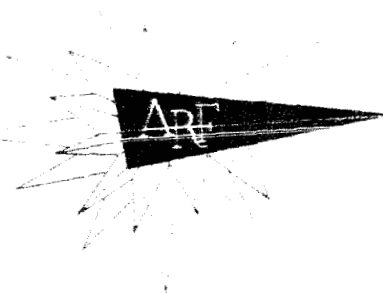
LIFE IN EXTRATERRESTRIAL ENVIRONMENTS

Kenneth E. Basa
Ervin J. Hawrylewicz

National Aeronautics and Space Administration
Washington, D. C.

Contract No. NASr-22

25 years of research



Report No. ARF 3194-1
(Quarterly Status Report)

National Aeronautics and Space Administration
LIFE IN EXTRATERRESTRIAL ENVIRONMENTS

ARF Project C 194
Contract No. NASr-22

February 15 to May 15, 1961

I. INTRODUCTION

The purpose of the program is to study the possibility of growing various forms of terrestrial organisms in simulated extraterrestrial atmospheres. The ability of certain forms of life to survive extremely adverse conditions is well known. With the advent of space flights and space exploration, it is necessary that this ability be examined within the framework of the environmental conditions existing on other planets of the solar system. The information derived from a study of this nature would be of importance in determining the ability of life to survive on other planets.

The objectives of the program are therefore as follows:

1. To provide information on the existence of life on other planets
2. To determine whether terrestrial life can contaminate other solar bodies
3. To consider the possible logistic application of microorganisms grown under extraterrestrial conditions
4. To obtain information on the physiology of specimens grown under these conditions and to apply this information to theories on the development of living "particles."

II. LITERATURE SEARCH

The initial step of this investigation was a literature search, undertaken to assemble data on conditions existing upon the planets. The paper and books reviewed are appended to this report as a reference list. Since numerous authors have expressed the opinion that Martian vegetation, if it exists, consists of lichenlike plants, literature regarding lichens was also reviewed.

III. LABORATORY STUDIES

Water and gaseous carbon dioxide are essential for photosynthesis, the basic energy source for most life on Earth. These two compounds are in their proper physical state in the atmosphere only if the planet remains at a prescribed distance from the sun. This distance is a function of the quantity, the quality, and the stability of the sun's radiation. The volume of space surrounding the sun in which radiation is optimal for photosynthesis is called an ecosphere. Only if a planet's orbit lies entirely within an ecosphere can that planet support life, as known on earth.

The ecosphere associated with the solar system contains the orbits of Venus, Earth, and Mars plus the natural satellites of the last two. Consideration of the environments of these six bodies led to the decision to make the initial studies on Martian conditions. Since lichens grow extremely slowly and are propagated by not too well-defined means, only the algal component of lichens was used in the present studies. A majority of lichens possess as the algal partner species of the genus Trebouxia, a unicellular green alga sometimes found living free in nature.

The following species of Trebouxia were grown on a medium consisting of inorganic salts, proteose peptone, soil extract, glucose, agar, and water: T. anticipata, T. impressa, T. gelatinosa, T. lambii, T. erici, and T. incrustata. Because of its relatively rapid growth rate and its hardiness, T. erici was selected for initial experimentation.

Present efforts are concerned with assembling the apparatus required to produce Martian environment in test tubes. Martian environment, as determined from the most recent literature, is defined for experimental purposes as follows:

1. Atmosphere: nitrogen, 95.7%; argon, 4%; carbon dioxide, 0.3%; pressure, 85 mm Hg
2. Temperature: daily variation, 12 hr at 25 °C and 12 hr at -60 °C
3. Soil: bright areas, feldspar or limonite (aluminum silicate or hydrated ferric oxide, respectively); dark areas, solidified lava (basalt or igneous rock)
4. Water: none added; trace remaining after lyophilization or Martian conditioning will simulate the trace of water assumed to be in the Martian atmosphere; this is less than 1%
5. Light: 500 ft-candles; the blue and ultraviolet light are presumed to be excluded by the Martian atmospheric haze.

IV. FUTURE PROGRAM

In the coming period T. erici will be placed in the simulated Martian environment, with suitable controls used throughout the experiments. Two additional strains of algae, received from Dr. Vernon Ahmadian of Clark University, will also be investigated. These were isolated from lichens

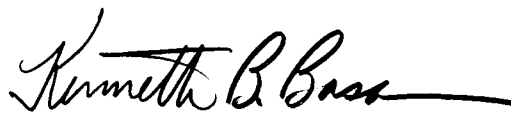
growing in the antarctic and are known for their ability to withstand adverse conditions in a desiccated state. In addition to the above, the literature on autotrophic bacteria in relation to extraterrestrial conditions will be reviewed. The bacterial studies will be initiated after the algal experiments have commenced.

V. RECORDS

The data from these studies are recorded in ARF Logbook C 11194.

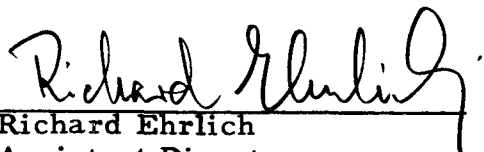
Respectfully submitted,

ARMOUR RESEARCH FOUNDATION
of Illinois Institute of Technology



Kenneth B. Basa
Assistant Bacteriologist

Approved by:



Richard Ehrlich
Assistant Director
of Life Sciences Research



E. J. Hawrylewicz
Research Biochemist-Group Leader

KBB/EJH/cg
5-15-61

REFERENCES

1. Ahmadjian, V. Antartic lichen algae. *Carolina Tips* 21, No. 5, 17-18, 1958.
2. Ahmadjian, V. A guide for the identification of algae occurring as lichen symbionts. *Botaniska Notiser* III, 632-644, 1958.
3. Ahmadjian, V. The taxonomy and physiology of lichen algae and problems of lichen synthesis. Ph. D. Thesis, 1959. Harvard University, Mass.
4. Ahmadjian, V. Experimental observations on the algal genus Trebouxia de Puymaly. *Svensk Botanisk Tidskrift* 53, 71-48, 1959.
5. Ahmadjian, V. A contribution toward lichen synthesis. *Mycologia* 51, 56-60, 1959.
6. Ahmadjian, V. The lichen association. *The Bryologist* 63, 250-254, 1960.
7. Ahmadjian, V. Some new and interesting species of Trebouxia, a genus of lichenized algae. *Am. J. Botany* 47, 677-683, 1960.
8. Ahmadjian, V. and Henriksson, E. Parasitic relationship between two culturally isolated and unrecated lichen components. *Science* 130, 1251, 1959.
9. Ahmadjian, V. and Reynolds, J. T. Production of biologically active compounds by isolated lichenized fungi. *Science* 133, 700-701, 1960.
10. Almy, E. G., Griffin, W. C. and Wilcox, C. S. Fischer volumetric determination of water. *Ind. Eng. Chem., Anal. Ed.*, 12, 392-396, 1940.
11. Anon. Growing fresh-water algae in the laboratory. Turtox service leaflet No. 6. Gen. Biol. Supply House, Chicago, 1949.
12. Anon. Gardens for space. *Boeing Mag.* pp 6-7, July, 1959.
13. Anon. Earth bacteria could survive moon's heat. *Science News Letter*, Feb. 20, 1960.
14. Anon. Probe for life on Mars. *Science News Letter* 78, 125, 1960.
15. Anon. Moon landing in 1962. *Science News Letter* 78, 279, 1960.
16. Briggs, M. H., and Revill, J. P. The chemistry of Mars. I. The atmosphere. *J. Brit. Interplanetary Soc.* 17, 391-393.

17. Bryant, W. M. D. , Mitchell, J. , Jr. , Smith, D. M. , and Ashby, E. C. Analytic procedures employing Karl Fischer reagent. VIII. The determination of water of hydration in salts. J. Am. Chem. Soc. 63, 2924-2927, 1941.
18. Calkins, K. Hot spots on the moon. Boeing Mag. , Feb. 1961.
19. Condon, E. J. "Electromagnetic waves," in Handbook of Physics. Chap. 1 of Part 6 - Optics. pp. 6-30, 1958. McGraw-Hill Book Co. , Inc. , New York.
20. Davis, I. , and Fulton, J. D. Microbiologic studies on ecologic considerations of the Martian environment. Aeromedical Reviews 2-60. School of Aviation Medicine, USAF, Brooks AFB, Texas.
21. Dollfus, A. Polarimetric and photometric observations indicating a possibility of life on Mars. Publ. Astron. Soc. Pacific 70, 50, 1958.
22. Fox, S. W. How did life begin? Science 132, 200-208, 1960.
23. Herzberg, G. The atmospheres of the planets. J. Royal Astron. Soc. Can. XLV, 100-123, 1951.
24. Hess, S. L. and Panofsky, H. S. "The atmospheres of the other planets," in Compendium of Meteorology. Am. Meteorol. Soc. , Boston, 1951, ed. T. F. Malone, pp. 391-397.
25. Huang, Su-Shu. Occurrence of life in the universe. Am. Scientist 47, 397-402, 1959.
26. Huang, Su-Shu. Life outside the solar system. Sci. American 202, No. 4, 55-64, 1960.
27. Jury, W. Round trip to the red planet. Boeing Mag. , May, 1960.
28. Kooistra, J. A. , Mitchell, R. B. , and Strughold, H. The behavior of microorganisms under simulated Martian environmental conditions. Publ. Astron. Soc. Pacific 70, 63, 1958.
29. Kuiper, G. P. Planetary and satellite atmospheres. Repts. Progr. Phys. 13, 247-275, 1950.
30. Kuiper, G. P. "Planetary atmospheres and their origin," in The Atmospheres of the Earth and Planets, Rev. Ed. p. 387, 1951. University of Chicago Press.
31. Kuiper, G. P. Visual observation of Mars. J. Astrophys. 125, 307-317, 1957.
32. Lamb, I. M. Lichens. Sci. American 201, No. 4, 144-156, Oct. 1959.
33. Levitt, I. M. A Space Traveler's Guide to Mars. 1956. Henry Holt and Co. , New York.

34. Miller, S. L. and Urey, H. C. Organic compound synthesis on the primitive earth. Science 130, 245-251, 1959.
35. Mish, L. B. Biological studies of symbiosis between the alga and fungus in the rock lichen, Unbilicaria Papulosa. Ph. D. Thesis, 1953, Harvard University, Cambridge, Mass.
36. Mitchell, J., Jr., Smith, D. M., Ashby, E. C., and Bryant, W. M. D. Analytical procedures employing Karl Fischer reagent. IX. Reactions with inorganic oxides and related compounds, oxidation and reduction reactions. J. Am. Chem. Soc. 63, 2927-2930, 1941.
31. Opik, E. J. The atmosphere and haze of Mars. J. Geophys. Res. 65, 3057-3063, 1960.
32. Pearl, Richard M. How to Know the Minerals and Rocks, pp. 185, 1957. New American Library of World Literature, Inc., New York.
33. Shapley, H. Extraterrestrial life. Astronautics 5, No. 4, 32, April 1960.
34. Sinton, W. M. Spectroscopic evidence for vegetations on Mars. J. Astrophys. 126, 231-239, 1957.
35. Sinton, W. M. Further evidence for vegetation on Mars. Science 130, 1234-1237, 1959.
36. Smith, D. M., Bryant, W. M. D., and Mitchell, J, Jr. Analytical procedures employing Karl Fischer reagent. I. Nature of the reagent. J. Am. Chem. Soc. 60, 2402-2412, 1939.
37. Starr, R. C. The culture collection of algae at Indiana University. Am. J. Bot. 47, 67-86, 1960.
38. Strughold, H. Life on Mars in view of physiological principles. In Epitome of Space Medicine, Art. 3. Special Report, USAF School of Aviation Medicine, Randolph Field, Texas.
39. Strughold, H. Ecological aspects of planetary atmospheres with special reference to Mars. In Epitome of Space Medicine, Art. 17. J. Aviation Med. 23, 130-140, 1952.
40. Strughold, H. Comparative ecological study of the chemistry of the planetary atmospheres. In Epitome of Space Medicine, Art. 8. Special Report, USAF School of Aviation Medicine, Randolph Field, Texas.
41. Strughold, H. The possibilities of an inhabitable extraterrestrial environment reachable from the earth. J. Aviation Med. 28, 507-512, 1957.

42. Strughold, H. Advances in astrobiology. Proc. Lunar and Planetary Exploration Colloq. 1, No. 6, 1-7, 1959.
43. Tiffany, L. H. Algae, the Grass of Many Waters, 2nd ed. , 1958. Charles C. Thomas, Springfield, Ill.
44. Tikhov, G. A. Is life possible on other planets? J. Brit. Astron. Assoc. 65, 193, 1955.
45. Vaucouleurs, G. de. The Planet Mars. Trans. P. A. Moore, 1950. Faber and Faber, Ltd. , London.
46. Vaucouleurs, G. de. Physics of the Planet Mars, 1954. Faber and Faber, Ltd. , London.
47. Whipple, F. L. Earth, moon, and planets, 1952. Cambridge Harvard University Press.
48. Wilson, A. Problems common to the fields of astronomy and biology. Publ. Astron. Soc. Pacific 70, 41, 1958.

DISTRIBUTION LIST

Copy No. 13

This report is being distributed as follows:

<u>Copy No.</u>	<u>Recipient</u>
1 - 25	Office of Research Grants and Contracts Code BG National Aeronautics and Space Administration Washington 25, D. C.
26	Armour Research Foundation Division C Files
27	Armour Research Foundation Editors, G. S. Gordon, L. C. Kinney, F. Schossberger, Main Files
28	Armour Research Foundation K. W. Miller, Report Library